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NOTES DURING A JOURNEY IN GUATEMALA, MARCH
TO DECEMBER, 1902.

BY

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INTRODUCTORY.

The following notes are based upon two visits to Guatemala. The first was made in 1880 and 1881, and lasted about one year. During this time I explored, principally on foot, the northeastern, eastern, and southern parts of the Republic. My second journey was due to a special mission intrusted to me by Mrs. Ph. A. Hearst, and lasted from March to December, 1902. During this time I visited principally the western and southern part of the country. The considerable interval between my two journeys has enabled me to note many changes which have taken place as regards biological, botanical, zoological, as well as agricultural aspects—changes which must greatly be regretted by every lover of the matchless nature which Guatemala shares with the rest of Central America. It has been frequently presumed that the luxuriant nature of a tropical country would rapidly heal the wounds inflicted by man's thoughtlessness, and that an abundance of rain and sunshine would soon

replace the devastated forests, as well as re-animate them with birds and other animal life; but a careful study shows that this is not the case. In the tropics, as well as outside of these regions, the rule seems to be that nature is slow in healing the wounds inflicted by the methods which man commands, and that, here as elsewhere, what is once gone, is gone forever. During the last twenty years the whole aspect of the coast region of Guatemala has completely changed. The former forests have given place to plantations. In many places these have been since deserted; but the tropical forests have not returned, and many of their former inhabitants have become extinct. Where once deep soil covered the rock, the destruction of the trees has been followed by the washing away of the soil and the laying bare of the bed-rock, just as in our own country. As a personal narrative would occupy too much space, I have here simply condensed some notes of more general interest.

THE PACIFIC SHORE-LINE, ITS ASPECTS, RAINFALL AND OTHER CLIMATIC CONDITIONS.

Travelling from San Francisco, California, along the Pacific coast of the continent to Central America we pass through three distinct climatic zones. The "extra-tropical arid zone" characterises Alta and Baja California, as far down the coast as the Cape Region of the latter country. The "tropical arid zone" begins with the Cape Region of Baja California and continues as far down as the town of San Benito, near the boundary of Guatemala. The "moist tropical zone" again begins in the vicinity of San Benito, and continues southwards below the equatorial region of South America. These three zones are quite distinct one from the other, though at the points of contact the transitions are somewhat gradual.

The "extra-tropical arid zone" is characterized by dry summers, during which dense and cold fogs are only too frequent even some little distance inland from the coast. The winters, again, are rainy, as a rule without any fogs, but with heavy frosts, especially in the interior valleys back of the coast. These winter rains, which all originate from *lows* in the Pacific Ocean off the coast of Alaska and British Columbia, diminish in intensity as we go farther south. While they never fail in California proper or Alta California, they become very scant and irregular along the coast of Baja California. As far down as San Quentin these rains seldom fail, but south of that point they become scarcer and lighter, until at Magdalena Bay they occur only once in three or four years. A characteristic of these rains of the extra-tropical arid zone is that

they are rarely accompanied by thunder and lightning, and may consequently be termed gentle rains, the word applying both to the quantity of the rain and to the force with which it descends.

South of San Quentin begins a short transition zone towards the tropical arid zone. As the winter rains become scarcer the tropical rains of the next zone become more frequent during the summer months—June to November. They do not occur, however, yearly, but at intervals of from one to three or more years. But as we near the Cape Region these tropical rains become more frequent, and from the vicinity of Todos Santos south of Magdalena Bay they may be considered as of yearly occurrence.

The “tropical arid zone” may be said to be fully characterized at the northern boundary of the Cape Region, though even here the influence of the northern winters makes itself felt at rare intervals. This influence manifests itself in the shape of occasional fogs, and in gentle rains, during December and January. In the vicinity of San José del Cabo such rains and fogs occur at intervals of one to several years. As a rule, the tropical arid region of the Pacific coast is characterized by rainy summers, the rain beginning in June and lasting to November. But even in this zone the change is gradual and irregular. While north of the Cabo San Lucas the rains on the Gulf coast begin frequently as early as the middle of June, they may in the vicinity of San José del Cabo seldom be looked for before September. However, as we enter the Mexican mainland on the Pacific, the summer rains become more frequent, as well as heavier. From Mazatlan southwards the months of June to October can always be counted on as rainy, though even here the rains are irregular and capricious. As we go south, in this zone, the rainfall increases in quantity as the season lengthens, but this increase in quantity and in time is much less marked than in the extra-tropical arid zone. This feature of homogeneity in the distribution of the rainfall in this zone is undoubtedly due to the physico-geographical features of the coast and the land back of it. We must remember that, while the rains of the extra-tropical arid zone originate in the Alaskan region, those of the tropical arid zone come from the evaportations and *lows* in the Gulf of Mexico. This solitary influence of the Gulf of Mexico extends as far as the southern boundary of the Gulf of Tehuantepec or the isthmus of the same name. South of this point precipitation is influenced by two sources of *lows*—one in the Gulf of Mexico, the other in the Caribbean Sea.

To this difference in the precipitation of rain, both as regards quantity and time, along the Pacific coast, is due the characteristic

appearance of the coast-line. Along the coast of California the forests rarely descend to the shore-line. This is especially the case south of Point Conception. The shore hills are here mostly bare or sparsely wooded with oaks; while upon the higher ridges may be seen pine and other conifers. During the rainless months—May—November—this coast presents to the traveller an uninterrupted waste of yellow rounded hills, only here and there dotted with darker live-oaks. As we approach the boundaries of Baja California even this remnant of evergreen trees and shrubs becomes scarcer, until at last south of San Diego they entirely cease. Along the coast of Baja California we look in vain for any traces of shore forests. Seen from the ocean the coast appears extremely barren, and only here and there do we find at the mouths of cañons clumps of cottonwoods, or mesquite trees. An exception to this so very barren aspect of the shore-line is seen on the island of Cedros, where the higher ridges near the shore are covered with pines.

As we enter the tropical arid region the shore aspect becomes less forbidding. At San José del Cabo a fringe of cocoa palms marks the shore; while during the rainy seasons the hills near and far are covered with a dense verdure, resulting from innumerable species of acacia-like shrubs and trees.

South of Mazatlan we meet, for the first time, with denser forests along the ocean shore. The part nearest the water's edge is always occupied by a thin belt of palms, principally cocoa and cocoayol palms. Behind this belt we find here and there, especially where the soil is of an alluvial nature, more or less broad belts of tropical forest of evergreen dicotyledonous trees. But in all this Mexican region the hills immediately above the coast-line are comparatively bare of evergreens, and principally covered with shrubs and small trees with deciduous leaves.

From the northern part almost of Baja California to the vicinity of San Benito, near the Guatemala boundary, the traveller beholds a backbone ridge—a sierra—with sharp peaks of generally fantastic shapes. These are bare of trees, but prominent on account of their rocky nature, which the seasonal rains have never been able to cover with an evergreen vegetation. This is the general aspect of the country as far down as the Isthmus of Tehuantepec. In the vicinity of the isthmus the interior sierra has dwindled to low rounded hills, while the immediate coast-line has preserved its barren aspect, due to irregular and not overabundant rains. But at San Benito we suddenly perceive a great change. The barren rocks, formerly so common and so monotonous, disappear entirely, giving place to an

evergreen tropical vegetation of shrubs and forests. The continuous belt of cocoa palms along the shore gives place to mangrove swamp-plants, of low height, the palms retreating to the higher inland hills. The fantastic peaks of an interior sierra have been replaced by an immense cordillera so densely covered with vegetation that not a bare rock or stone can be seen anywhere. From this general cordillera there rises, at certain measured intervals, a succession of volcanic cones of surpassing beauty and grandeur.

CLIMATIC CONDITIONS OF GUATEMALA.

Guatemala is situated between $13^{\circ} 42'$ and $17^{\circ} 48'$ lat. N., and $88^{\circ} 10'$ and $92^{\circ} 30'$ lon. W. Greenwich. While this situation determines the general climatological conditions of Guatemala, it does neither account for the climatic peculiarities of the country as compared with those of the adjoining countries, nor for the differences in climatic conditions of the various parts of the Republic itself. The main factors which regulate these conditions are the height and extent of the mountain regions. By far the greater part of Guatemala consists of an elevated mountain-complex, which is further subdivided into a complex system of mountain ridges separated by more or less elevated valleys. It is to be regretted that this country, as well as the rest of Central America and Mexico, has never been properly surveyed, and that the existing maps are in many respects incorrect. As regards meteorological records, the case is aggravated by the carelessness of the observers of the few existing stations and the absence of scientific interest with which their observations have been made. The scarcity of the stations is such that it is at present impossible to form any correct idea of the origin and movements of the *lows*, upon which the general rainfall is dependent. The main feature which distinguishes Central America from Mexico is that the former country receives its rainfall from two distinct sources at the same time—*lows* originating both over the Pacific Ocean and over the Caribbean Sea. This insures a much greater and more evenly distributed rainfall to Central America than to Mexico. This is the principal difference between the two countries. The differences depending upon changes in temperature are slighter, as both countries are elevated and, as regards their interior tablelands, often visited by heavy frosts, which in the highest places are of great continuity and often intense. The main climatic factors are, then, the humidity of the air, the temperature and the rainfall, each of which will now be considered more in detail.

HUMIDITY OF THE AIR.

As might be expected in a country situated between two tropical oceans, the humidity of the air in Guatemala is very great. There are, however, considerable differences in different localities. As a rule, it may be said that in the mountain region and in the low coast-belt the humidity of the air approaches a more perfect saturation than in the interior valleys. The northern mountain region is much more humid than the southern, and the Atlantic coast is much more moist than the Pacific. On the Pacific side the saturated air-belt stretches along the whole coast from San Benito, in Mexico, far south towards the equator. In width this moist belt extends from the Pacific shore-line for about thirty to forty miles inland to a line which runs more or less parallel with the shore, following the crest of the volcanic fissure along which are situated the volcanic peaks. On the Atlantic side, as well as on the northern border, this moist belt is broader. The ascent of the land from the coast is on that side more gradual, and the mountains, as a rule, are less elevated. The moist belt-line is on that side more irregular and ends less abruptly than on the Pacific side. Roughly speaking, a line running east and west passing through Huehuetenango, Salamá, and Zacápa divides the extremely moist zone from the one less moist. To the north of this line we have the high mountain-complex, in which all the largest rivers in Guatemala and Mexico have their head-waters; while to the south of that line we meet with interior valleys more or less surrounded by high mountains, and which are characterized by a comparatively low humidity of the air. Going from west to east, this humidity of the air decreases, as is clearly seen if the valleys of Huehuetenango, Quiché, and Salamá are compared. This is due to the fact that the valley of the Rio Grande or Motagua, which runs from west to east, is much lower than any of the other inland valleys, the moisture thus having been precipitated on the surrounding high mountains before it reaches the basin below. The decrease of moisture is so great that the basin of Salamá and a great part of the Motagua basin partake to a considerable extent of the nature of a desert region in which crops require to be irrigated by artificial means.

The interior tablelands, extending from the coast cordillera on the Pacific side to the high mountain complex mentioned above, enjoy a comparatively moist air both in winter and summer, the moisture, however, being less than in the belt surrounding them.

But even within a territory in which we might expect an even distribution there are found great differences, difficult to account

for. These will be further considered in connection with the botanical zones; here we will only state that everywhere the humidity of the air is much greater in the forests than in the open country. This may be readily observed in places where the formerly impenetrable forests have been cut down in order to leave room for plantations. But even in places where no such destruction has taken place we meet with vast areas in which the humidity of the air falls so low as to become insufficient for the wellbeing of most so-called tropical plants. This is especially marked in the regions of the savannas, in the highest part of the cordillera and the northern sierra, and in the valleys of Salamá. According to statistics furnished by the Laboratorio Químico Central in Guatemala, the greatest saturation takes place just before sunrise. In Guatemala City the average humidity at that hour throughout the year is 89%; while at noon it is 69%, and at 9 P.M. 87%. In Alta Verapaz, at nearly the same altitude (4,883 ft.), these numbers would be respectively 95%, 72%, and 86%.

RAINFALL.

The abundance of the rainfall in Guatemala is, as has already been stated, due to *lows* on either side of the continent. In the zone situated north of the Huehuetenango and Zacápa line the precipitation takes place principally during northeast winds; while south of this line the rains are generally precipitated during southern winds. It is thus evident that we have here to deal with two systems of *lows*—one originating in the Pacific and the other in the gulfs of the Atlantic Ocean.

We can, in Guatemala, distinguish between three more or less distinct zones of precipitation; but, as a rule, it may be said that the rainy season lasts between the months April and November, the months from December to March being those in which the least rains fall. The first of these zones of precipitation is situated north and east of the Huehuetenango-Zacápa line, including the high northern sierra complex, with the Cobán region as well as the Atlantic slope. In this zone the rains are less confined within certain seasons. The rainiest months are those between April and November, but rain may be, and generally is, precipitated during every month in the year. Especially is this the case in the highest part of the sierra region and along its northern slopes—that is, the headwater-zone of the large rivers Usumacinta and Chiapas, Rio Polochic, and Cáhabón. In the zone of the Rio Chiapas daily fogs are the rule. These fogs degenerate into rain, which, while

sometimes gentle, generally finishes in tremendous downpours. The rain precipitation in this zone has never been accurately measured, but it is safe to say that it is by far the greatest in Guatemala, and that it reaches 6,000 millimetres or more (240 in.). In the eastern part of this large northern rainbelt the rainfall averages between 3,000 to 4,000 millimetres (120-160 inches), being less in the valleys of Rio Cáhabón than in the surrounding mountains.

The second zone of precipitation is situated south of the line Huehuetenango-Zacápa, and extends to the volcanic cordillera, which runs parallel with the Pacific coast. It occupies the whole of the large interior tableland of Guatemala, the principal part of the district being the valleys tributary to the Rio Grande or the Motagua. Of this zone the northeastern part is the driest, this part including the valley of Salamá, a tributary of the Usumacinta. Here the moisture and rainfall are especially scant at any time of the year, and a month or two may pass in the middle of the rainy season without any precipitation. The explanation is that the moisture in the air, carried to these interior valleys by northern winds, has already been precipitated on the northern slope of the surrounding sierra. The change from the dry plains around Salamá to the moist ones of Cobán is most marked and interesting. Ascending from Salamá the high mountain crest which separates the two places, the traveller has to pass for ten leagues over comparatively barren hills, on which not even drinking water is found during the dry season. But upon arriving across the range he finds himself, without any warning, in a paradise of freshness, where every acre of the ground is watered by springs, and where the soil is clothed with eternal verdure.

The valley of the Rio Grande is especially dry and inhospitable to vegetation, resembling, during the dry season of the year, the barren hills of the Mexican Pacific shore. As we proceed towards Guatemala City the rainfall increases, and the aspect of the vegetation is less barren. It is to be remarked that in all this interior zone the mountains are more favoured with precipitation than the valleys. A few hundred or a thousand feet may make considerable difference in the rainfall of the respective localities. The amount of rainfall in this zone varies considerably. In Guatemala City the precipitation averages 1,500 millimetres (60 in.). In Salamá it averages 600 millimetres (24 in.); in Quezaltenango, on the eastern border of the zone, it is somewhat more than in Salamá, or about 700 millimetres (28 in.). In this interior zone the dry season is well and clearly separated from the rainy one. The rains seldom

begin in earnest before May, and they generally finish in October. The months from October to April may be counted as dry, though exceptions may occur. The precipitations in this zone are, however, far from continuous or of daily occurrence. In the beginning of the rainy season we may expect a shower every afternoon for some days in succession; then several days may pass in which there is no rain. A more prolonged spell of continuous dry weather is regularly experienced in the middle of August, when, according to expectation, no rain falls for two weeks. The year of my first visit this dry period occupied fifteen days; while during my recent journey no rain fell for five weeks.

In this zone the first rains are expected at the end of April or the beginning of May. The popular idea is that it always rains in the City of Guatemala on the 4th of May, but, like all other popular beliefs, this one is not to be relied upon; statistics show that rains commence in April as often as in May. The first showers are generally, if not always, accompanied by thunder and lightning. For weeks previous the sky is generally overcast with apparent thunderclouds during the middle of the day, though no precipitation results. Later on, the mornings are clear and bright; but at noon clouds are seen gathering in the south, and between 1 P.M. and 2 P.M. a thundershower may be expected.

This is repeated, on an average, about fifteen times during each of the months June, July and September, with a perceptible falling off in August. In October and November the thundershowers are rare, the rains then being of a drizzly nature, like those on the coast of California. At the end of the rainy season the sky does not clear at once, but remains cloudy for days, or even for several weeks, after precipitation has ceased. But instead of clouding up only in the middle of the day, we find that at this period already the mornings are cloudy, while the middle of the day is clear.

In this zone, as well as in the two other zones, the precipitation takes place during the height of the rainy season twice a day. As stated, the first showers commence rather regularly between 1 P.M. and 2 P.M., lasting up to one or two hours, or less. In the evening, between 7 P.M. and 9 P.M., another rain may be expected of from one to several hours' duration. In this zone, as well as in the two other zones, rain in the morning and forenoon is of extremely rare occurrence, and the traveller can nearly always count upon fair weather from 4 A.M. to 12 noon in any part of Guatemala.

The third zone of precipitation extends from the Gulf of Tehuantepec along the coast of Guatemala past its southern boundaries.

This zone is characterized by a much greater amount of rainfall than the interior zone, but by a lesser one than the northern zone. In this coast region we may also distinguish two seasons—one dry and one wet. The dry season occupies the months of December to April, the wet one the remainder of the year. Nearly the whole of the precipitation comes in the nature of thundershowers, gentle rains being of rare occurrence. The rain always comes with southern winds, and with accumulation of clouds along the crest of the coast cordillera. It is heavier along the slopes of the cordillera than farther down along the coast. The quantity may be considered as somewhere near 4,000 millimetres (160 in.). The rainy season begins about the same time as in the interior, or in March to May, but it lasts about a month longer than in the interior. The rains are generally accompanied by heavy winds, which, during the height of the season, are of great force, but of short duration.

There are two periods of precipitation daily—one between 1 P.M. and 8 P.M., the other from 8 P.M. to 9 P.M. A third period is often in the morning hours, between 2 A.M. and 4 A.M. Between these periods of daily precipitation the sky clears along the lowlands, though along the crest of the cordillera the volcanic peaks are nearly always obscured, except from 6 A.M. to 8 A.M., when they may be clearly seen. The rainfall diminishes towards the southeast to such an extent that there is probably a difference of about 1,000 millimetres (40 in.) between that of the boundary line of Mexico and that of Salvador, the main cause being, probably, the diminished height of the cordillera towards the southeast. The greater rainfall in the region known as the Costa Cuca may also be due to the fact that this part receives also precipitation from *lows* originating in the Gulf of Mexico, but rarely extending south of the point of San José.

TEMPERATURE.

There are two maxima and two minima annually, according to the position of the sun. The maxima occur in April–May and August, and the minima in July and December–January. The maximum in July is tempered by the cloudy skies and the rainy spells of the winter months, while the minimum in January is moderated by the dry air and the constant sunshine during that time. The daily fluctuation of temperature shows that the lowest point is reached at sunrise, while the highest is registered at about 2 P.M.

The mean temperature in the City of Guatemala is, indoors, 74° Fahr., while out-of-doors it is 66°. In the sun it seldom reaches 86°. From sporadic observations made by travellers and a few per-

manent settlers it is supposed that the mean temperature of Salamá is 74°; that of Quezaltenango, 58°; that of Port Barrios, 78°.

The frost-line of the Pacific slope coincides with a line passing along the crest of the cordillera at an altitude of about 4,000 feet. This is also the altitude of the base-line upon which rest the pyramidal cones of the volcanoes and the passes situated between them. On the coast side of these passes and below them frosts are unknown, but slightly interior to the passes frosts occur at rare intervals, increasing in frequency with the altitude. The frost-line marks the limit for the cultivation of the coffee tree, and, to some extent, for the profitable production of sugar-cane. But it is interesting to note that the best coffee, as well as the best sugar, is produced close to the frost-line, such coffee and sugar being more highly flavoured than that grown in the warmer lowlands.

The practical experience as regards the wellbeing of man in Guatemala is that, except for the narrow coast-belt, the temperature is comfortable and agreeable, and, as regards sensation, almost ideal, both winter and summer.

ELECTRIC STORMS AND CIRCULAR LIGHTNINGS.

Thunderstorms are characteristic of all parts of Guatemala, but especially so of the Pacific coast along the cordillera and in the highlands of Alta Verapaz. In the high mountainous complex of the Departments of Huehuetenango and Quiché they are comparatively rare, though along the interior valleys they are more frequent. During a journey from Chaculá, on the Mexican border, to Aguacatán, I was told everywhere that thunderstorms were rare. During my stay there we had no thunderstorms, though heavy rains were of daily occurrence. During the months of November to January electrical storms are rare, though they do occur. During this time the sky is generally clear during the early part of the day, and magnificent distant views may be had, which is not the case during the months from April to October.

The intensity and frequency of the lightning flashes during the height of the rainy season are something extraordinary. During a single evening, while travelling from San Juan Sacatepeque to the City of Guatemala, I counted more than one thousand lightnings from a single group of clouds in the direction of Tecuamburro, which locality seemed especially favourable to these phenomena, repeated almost every day for nearly a month (September).

Almost every traveller in tropical Central America has described what is known as "circular lightning." These lightnings occur

generally at the end of the rainy season, and are more frequent on the coast than in the interior. It has been supposed that they are due to a certain quality of electricity, differing in intensity from the ordinary. The observer sees no rays, but simply a disk-like flash in a cloud, with a perfect absence of electric streamers. During my stay in Guatemala I had frequent opportunity to observe this interesting phenomenon, and I think the explanation is not a difficult one. I am satisfied that there is no difference in quality nor in quantity in the electricity of the two kinds of lightning, but that the cause is the character of the clouds. While in countries outside of the tropics thunderclouds occupy, as a rule, a single stratum in the air, in Guatemala and other parts of Central America it is not unusual to find two, or even three, distinct strata of cumuli, one above the other. When electricity is discharged from clouds arranged in a single stratum, the discharge takes place either between the clouds and the earth or between two clouds approaching each other. The same may, of course, be the case when we have two strata of cumuli, one above the other. But sometimes this is not the case, and, when three strata of cumuli are superposed, regular electric streamers are rarely observed. Instead of discharging to the earth the discharge takes place between the respective strata exactly in the same manner as usual; but the fact that we then frequently see the discharges in the direction of their longitudinal axis prevents us from observing the streamers. For instance, the discharge takes place between two clouds, one above the other, the two being shielded from our view by a third lower one. We then see, not lightning streamers, but simply a single flash, which is reflected by the cloud-banks immediately surrounding it. During my night trip just referred to I had ample opportunity to observe this phenomenon, and out of the one thousand or more flashes observed, at least six hundred belonged to the circular class. Whenever there was a rift in the cloud-banks and the discharge was oblique to the axis of view the streamers were distinctly visible. Many times there were observed as many as three distinct electric discharges at the same moment. The central lightning, being hidden by a cloud, was then often circular, while the side flashes were seen to be streamers of the most pronounced nature. These, my first observations, were confirmed by many others, and I satisfied myself that circular lightning is simply an electric discharge between two or more small cumuli superposed on each other, the point of observation always being in the direction of the axis of discharge. Thus, what will appear

as a circular lightning to an observer placed in the extended axis of discharge, will appear as stream lightning to any one who sees the same discharge from a point of view outside of the prolongation of the above axis, and when both clouds are distinctly in view. Such circular lightnings have not been known to strike the earth, as the discharge is intercepted by the lower stratum of cumuli. Whenever the lower stratum of cumuli is continuous, all the flashes appear as circular or disk lightnings, but where breaks occur in the low stratum the lateral streamers become visible as such.

VEGETATION ZONES.

With a few exceptions, all the soil in Guatemala is covered by vegetation. In some localities this vegetation is scant and of an arid aspect, but, as a rule, it is of a tropically luxuriant nature. As in most countries which rise abruptly from the ocean, and which, besides, are characterized by immense interior highlands, zones of vegetation are well defined and highly characteristic. The student of geographical and physical botany has in Guatemala a wide and interesting field, as in few countries are there to be found such a variety of extensive vegetable zones. As elsewhere, these zones are determined by temperature, humidity, altitude, and exposure to winds. While these zones are scientifically very interesting, they are also of great economical importance, and the horticulturist must take them into consideration if he hopes to succeed in making profitable investment. Each one of these zones of vegetation is also favourable or unsuitable to certain economic plants, both native and imported ones, and the prosperity of the country is thus dependent upon a proper understanding of the nature and extent of the different zones.

The general opinion of those who are not acquainted with the tropics of Central America is that the country is intensely hot and moist, and more or less unfit for one born in northern or more temperate latitudes. As regards Guatemala this opinion is especially erroneous. With the exception of a comparatively narrow strip along the two oceans the Guatemala climate is temperate, and tropical only as regards absence of extremes of temperature. Considering only the larger and more strikingly distinct zones, we may limit them to two—the great littoral region along the shore of the Atlantic and the Pacific oceans and the great interior highlands. If we count in the almost unpopulated or rather uncultivated region occupied by the territory or Department of Petén—which, of course, is not littoral—the former region occupies about one-half of the

whole Republic. This half may be considered as warm and moist, with no great distinction between a dry and a rainy season. The other region, comprising the tablelands, is characterized as dryer and more temperate, with a distinct division into a dry and moist season. But upon a closer examination we find that this general section is not strictly correct, though it gives a rough general idea of the nature of the country. As the nature of the vegetation zones depends upon three or four different factors, it becomes evident that, according to the various combinations of these factors, the result must be several distinct zones of vegetation. These we will now consider somewhat more in detail.

THE LITTORAL SALINE ZONE.

This zone occupies the fringe of the Pacific shore and, to some extent, that of the Atlantic side, wherever the shore is low and covered with larger and smaller *esteros* or lagunes with salt or brackish water. Another name for this region is "mangrove swamps," though the vegetation is not alone confined to mangrove plants. This zone is very narrow, seldom more than a few miles in extent, and of varying length according to the height of the land above the high-water mark. Where the swamps are broken through by elevated or rocky projections the mangroves are replaced by tropically dense forests similar to those of the next zone. Such, for instance, is the case at the southern extremity of Guatemala near the boundary line of Salvador. The vegetation of the mangrove zone consists of evergreen shrubs or low trees, rarely over twenty feet in height. These thickets are always so dense that they may be considered impenetrable, except where canoes pass along the open channels of the *esteros*. This zone is unsuited to cultivation, except in places where the land rises above the saline swamps. In such localities cocoa palms and other tropical plants may be cultivated to a limited extent. This region is feared on account of the fevers; but the knowledge that the cause lies with the mosquitoes does not seem to have reached those who should be most interested in knowing it.

THE HUMID AND WARM ARBOREAL ZONE.

Wherever the saline *esteros* give place to higher lands we meet with impenetrable forests of majestic tropical trees. In Guatemala this zone occupies the littoral of the Pacific, the littoral of the Atlantic, the Bay of Honduras, the northern slope of the northern sierra complex occupying the Departments of Huehuetenango and

Alta Verapaz, and also the larger part of the immense territory of Petén. These originally impenetrable forests extend in some places from the waters of the ocean to an altitude of over 10,000 feet on the slope of the Pacific coast cordillera. On the northern slope of the northern sierra these forests gradually merge into those of the next zone; but I incline to think that they do not reach as high an altitude as on the Pacific side. The forests in this zone are composed of dicotyledonous trees of tropical genera and species in great variety. The trees are evergreens, and many are of great height. The most prominent trees of this zone are the *ceiba*, in many species, and the gigantic figtrees or *higuerones*. The ceiba must be considered as the largest tree in Central America, not perhaps as regards height, but certainly when bulk is considered. The forests in which these trees grow are characterized by their density, due not alone to the undergrowth of smaller plants and the close proximity of the large trees, but principally to the impenetrable growth of parasitic plants of various nature. With a few exceptions, every tree is a botanical garden in itself, covered with climbing aroids, with morning-glories (*Ipomea*), with ferns and orchids. The exception to this is found in a very few tall and slender trees which shed their bark annually. On such trees the climbers do not get a hold, but are shed with the bark of the tree. The most remarkable tree of this nature is called the *Tumbador*, with leaves like a papilionaceous plant, to which family it probably belongs. The stem of the tree is slender, without branches except at the top, and the bark is smooth and white—a striking exception among trees which are covered from top to root with a dense network of climbers, often to such an extent that only the very crown of the tree is visible.

The form of the trees in this zone is generally uniform. A tall, slender and erect trunk, free from branches; at the top of the trunk a large, broad umbrella-shaped crown, with powerful but elegant branches spreading evenly in all directions. The trees are commonly furnished with buttresses, which support the trunk and prevent it from toppling over or bending. The tall and unbranched trunk gives the minimum lodging to parasites, while the umbrella-shaped crown catches as much sun and air as possible. If trees of a different form were introduced into these forests and allowed to care for themselves they would soon succumb. The parasitic plants would soon break the branches of a tree that spread out close to the soil, while trees with narrow and upright crowns would not receive the necessary sun and air.

These forests are dependent upon moisture and a rich soil, and, to a lesser extent, upon temperature. While we find different species of trees composing the forests of the lower and upper parts of this zone, the general nature and aspect of the woods from the water-level to the crests of the cordillera are very much the same. Except where the soil differs or where the axe has interfered, the same forest covers the lower level lands and the slopes of the towering volcanoes, up to a certain height, where heavy frosts interfere with the growth of tropical plants.

Strictly speaking, however, this zone is not absolutely homogeneous. Wherever the soil is either poor, too sandy, or underlaid by hardpan, the forests give room to more open places, covered, not with tall trees, but with large and dense shrubs, in which the tall and slender bamboos take a prominent place. On the other hand, along the Pacific coast of Guatemala, we observe large dikes of lava rising in the shape of curiously-formed hills above the general level of the slope. On such *peñascos* the vegetation is less dense, but not the less interesting. However, as these localities are dependent only upon the nature of the soil for their distinctive vegetation, we do not classify them as distinct zones.

The magnificent forests are rapidly disappearing. At the time of my first visit to Guatemala the slopes of the volcanoes facing the Pacific were yet covered with them. In vain did I now hunt for these marvellous productions of a tropical nature in places where formerly they had attracted my attention. They had been cut and burnt, and sugar plantations or coffee *fincas* have taken their place, or herds of cattle pasture upon planted fields of *zacate* or forage. In twenty years more the Pacific coast will have no more primeval forests to show. The best preserved of the few remaining forests are found along the new coast railroad from Aguna to Mazatenango.

THE TEMPERATE ARBOREAL ZONE.

This zone occupies the interior of Guatemala from the crest of the Pacific coast cordillera to the humid region of the north and east. As soon as the traveller has passed the culminating backbone of the cordillera he finds himself in a region less humid and more temperate than that of the coast. The luxuriant vegetation of the volcanic slopes or of the dense forests of the Alta Verapaz has given place to more open forests of oak and pine. To a large extent, these forests have long ago been cut down and fields of maize and beans have taken their place. Originally the whole

country was undoubtedly covered with a continuous belt of these trees, the *barrancas* or the topmost ridges being the only places characterized by a more luxuriant growth. The aspect of this zone is that of a forest region of the temperate parts of the United States, especially the foothills of California. We meet with four or five different kinds of oak and one or two of pine. The oaks are generally small or of medium growth, a large tree being an exception. The small size of the oaks seems principally due to the shallowness of the soil, as in places where the soil is deep and rich the same varieties attain to much larger dimensions. Gigantic oaks like those of the North American forests are, however, nowhere to be found. As far as I know, all of the oaks are of the evergreen kind. The pines are generally small and branched, and only one species seems suitable for lumber. These straight and tall pines are principally found in the northern cordillera in places where the temperate and the humid zones interlace, as will be described further on. The undergrowth in this zone is not as dense as in the lower zone of the cordillera. The trees are to some extent covered with climbing morning-glories, while on the horizontal branches live orchids in great variety, some of the handsomest species being found on the oaks of this zone. In open places and along the edge of the forests the ground is covered by a large variety of magnificent *compositæ*, among which the sunflowers are especially noteworthy and beautiful. Thus on the slopes connecting the humid warm zone with the present one we find extensive fields of brilliant flowers, principally gold and white. Nothing is more charming than the aspect of the lands between the volcanic peaks, which at the end of the rainy season present a wealth of colour such as is seen in the meadows of the high north. The difference is, however, that while in the north the plants are of low growth, in the tropics they are tall and bushy and the flowers large and luxuriant. In this floral display the morning-glories take a prominent place. Every few miles we meet with different species, characterized by distinct colouring, shape, and size. Some are gigantic, while others are lilliputian in size. Among the most charming fields of this nature were those on the slopes of the Volcan de Agua and the western sides of the lakes of Amatitlan and Atitlan. Even in the high sierra of the Department of Huehuetenango immense fields of *compositæ* charm the traveller with their rich colours and their delicate perfume.

ZONAL WEDGES IN THE HIGH SIERRAS.

It is most natural to suppose that the two zones characteristic of the high sierra should follow each other with some regularity, as do the zones in more temperate regions outside of the tropics. But such is not the case; and this fact was one of those which appeared to me as of the greatest interest. The warm moist arboreal zone is everywhere in Guatemala known as the *Montaña*. It is characterized principally, while remaining in its primeval state of nature, by impenetrable evergreen forests of broad-leaved trees, bound together by dense thickets of climbers and parasitic plants, all indicating the immense fertility of tropical nature. The temperate arboreal zone is characterized by the scarcity of evergreen climbers, by the absence of an impenetrable undergrowth, by the presence of pines and other plants which indicate the more barren nature of a less luxuriant climate. In most countries such arboreal zones occupy different altitudes, the less luxuriant one being situated above the other. But in Guatemala this is not always the case. For instance, along the north and western slope of the high sierra, from Nenton towards the Mexican boundary and the western arm of the Rio Lacandon, we find that these two zones interlace with each other, occupying the same altitude side by side. Thus, for instance, in ascending from Chaculá (5,500 feet) to the higher altitudes of San Mateo Ixtatán, we can have our choice by passing through one or the other of these zones. Through the humid zone it is only with the greatest difficulty that we can make our way, every step being contested by *montaña*. But by following another trail, perhaps a mile to one side or the other, we may pass through comparatively dry pine forests, in which we look in vain for anything to remind us that we are in a tropical country, and by turning a little to the left or to the right, we can move from one zone of vegetation to the other. The main cause of this sudden change seems to be the drift of the clouds. If from a lower standpoint we observe the hills and the general movement of the clouds during the dry season, we find that day after day the clouds seek the same mountain slopes and tops. We may be absolutely certain that the slopes covered with cloud consist of *montaña* lands, while those which remain uncovered are clothed with pine forests. In this manner the two zones are often wedged into each other with great irregularity. The soil in the two zones is different. In the humid zone it is deep and black, and even during the dry season so wet that the trails are impassable. In the pine zone the soil is dry, shallow, and of chocolate colour, the very opposite to the former. This indicates that similar condi-

tions have existed from time immemorial—from the beginning, perhaps, of the Tertiary period. The most plausible explanation, if I may venture on one, of this phenomenon is that, owing to the configuration of the mountains and their situation between an upper colder zone and a lower warmer one, a certain regularity in the air currents has been established in such a manner that the cold currents always follow the same routes. Upon reaching the cold currents the moisture in the air condenses in the form of clouds, which, again, keep the vegetation green and luxuriant all the year round. As to the cause of these currents or zones of colder air, the configuration of the country and its mountain slopes has not given me any satisfactory clue.

The rock formation—of limestone bed-rock—is similar throughout, and there is no difference in the altitude of the two zones.

THE HUMID AND COLD ARBOREAL ZONE.

This zone occupies the high valleys of the northern sierra, as well as some of the upper slopes of the volcanoes. Its extent is not well defined, and it is less known than any of the other zones. The best samples of these magnificent forests are seen in the Departments of Huehuetenango and Alta Verapaz. Here we find them in the valleys connecting the high tablelands with the forests of the humid warm zone. In passing through Guatemala, from the capital northwards to the boundary of Mexico, we do not meet with any representatives of this zone until we reach the crest of the sierra north of Chiantla. Here we find that the oaks and pines of the tablelands of the last zone have given place to gigantic and magnificent cedars, vines, and cypress trees, with erect stems and large umbrella-shaped crowns. Nowhere have I seen anything in nature that has so inspired me with admiration and astonishment. No words can describe the beauty and magnificence of the trees. They stand close together, and, with a thick undergrowth of oaks and other semi-tropical trees, form masses of verdure, impenetrable alike to wind, and sun, and man. The clouds hang over these forests throughout the year, and the condensed fogs drip to the soil as an almost constant rain—at least during certain hours of the day. The individual trees are of majestic size and marvellous beauty, forming an assemblage perhaps not equalled elsewhere. The undergrowth consists of evergreen shrubs and smaller trees, especially of the family of *Vaccinæ*. Even the tropical forests of the coast-belt do not impress one as do these giants of the high sierra. On the higher rocky places the cedars are replaced by junipers hardly inferior in size and fully as beautiful in

form. The greatest altitude of this zone is about 12,000 feet, above which no trees are found. But as in this part of Guatemala few peaks reach any higher elevation, it is extremely rare to find any place not covered by dense forest. In the upper parts of this zone the traveller may expect to meet with heavy thundershowers and hailstorms during any time of the year, but especially during the months of June to September, and then principally in the early afternoon. During the rainy season these forests are rarely clear from fog or clouds more than a few hours in the forenoon. Already long before midday they cover themselves with clouds; while in the afternoon they are dripping with rain. The forests grow densely in the protected but precipitous valleys, the lower limit of which is about 7,000 to 8,000 feet in some localities; while perhaps only a few hundred yards away the lower limit is several thousand feet higher, the difference depending upon the currents of wind and the exposure. In these forests orchids are rare, and the density is not caused by parasites, but rather by the interlacing of trunks and branches. Happily for the preservation of these marvellous growths, few roads exist in these places, making it as yet unprofitable to export or utilize the lumber, but near the cultivated districts the trees have suffered much by fires started by the Indians. These forest lands are very fertile when once cleared, and in order to utilize them the natives cut some of the trees and then fire the brush. In this manner a great part has been destroyed. The worst consequence is that the land thus gained is not cultivated more than two years in succession. Already in the second year a new growth of different plants springs up, which the natives find too difficult to destroy. It is easier to fell new trees and to burn the ground over than to grub up the new weeds in the *milpas* (maize plantations). But where thus the old forests have been destroyed no new one of the same nature takes the place. The new growth consists of different trees, like those found in the temperate zone—oaks and low-growing pines. The cedars and cypresses do not return.

THE DRY AND WARM ZONE.

This zone, which is one of the best characterized, occupies certain valleys in the central part of Guatemala. These valleys are all surrounded by high mountains, on the slopes of which the humidity of the air has been precipitated before it reaches the valleys during the rainy season. Similarly, during the dry season the moist northern and eastern winds are prevented by the high ridges of the sierra from modifying the climate of these valleys. The deep river basins of the Rio Grande and the Motagua belong

to this zone, and so do the depressed plains around Salamá and Cáhabón in Alta Verapaz. The traveller who descends into either of these valleys from the surrounding high and moist ridges finds himself suddenly in a territory of different temperature and vegetation. The cool air of the ridges has given place to intensely hot and dry calms, in which even the shadows of the *barrancas* give little or no relief. The luxuriant vegetation of the ridges has been superseded by deciduous trees of small growth and dense thickets or *chaparrales* of thorny bushes, while the open places are characterized by desert types, such as cactus, yucca, agave, bromelias, and other plants of the arid region. In this zone no crops can be profitably grown without irrigation, except corn, which, however, is raised to a very limited extent. On account of their high temperature these valleys are classed as the *tierra caliente*. Here flourish the cocoa palm, the sugar-cane, and other tropical plants which cannot support the low temperature of the temperate zone. The arid nature of this zone is due to several circumstances combined. The first is the scanty rainfall. Another cause is that a layer of hard clay, sometimes even of a rocky nature, lies close below the topsoil and prevents the absorption of the rain. This is the case in the valley of the Salamá and in that of Cáhabón. Another reason is the comparatively low elevation of the valleys, that of Salamá being less than 3,000 feet. This depression accounts for the greater heat of these valleys. In the valley of Salamá we find the surface often barren, only here and there covered with low, globular cacti, between which are smaller herbs and grasses, not dense enough to hide the soil. On the slopes of the low hills around the valley we find among the low shrubs, known as *chaparral*, dwarf fan-palms or palmetto. For fences in this region the cultivator plants tall, columnar cacti, which soon after planting become impenetrable by cattle. In slightly elevated and stony places we meet with different varieties of cacti, some of which are of considerable height and of columnar and branching form, while others partake of the nature of broad-leaved opuntias. A characteristic tree planted along the roadsides is the *ojote*, its branches being peculiarly twisted and noded and covered with a shiny yellowish-brown bark. But this so apparently inhospitable zone presents during the dry months of the year a floral display entirely unexpected. At that time the chaparral bushes are covered with multicoloured flowers in great variety, and it is evident that in this region the botanist will find a rich harvest of as yet unknown species. As pasture grounds for cattle these plains or hillsides are poor and only suitable during the rainy season. During the dry season the cattle must be driven

to the mountains. With irrigation, however, this territory becomes immensely fertile, as may be seen in the many fine plantations of sugar-cane in the vicinity of Salamá.

THE SAVANNAS.

These zones, which are nowhere continuous, occupy a very limited territory in the high sierra and on the upper part of the volcanoes of the cordillera. The cause of the limitation of these zones is not known with certainty, but it appears that the influencing factors are intense cold and heavy, perhaps at times drying winds. In this zone we find few or no trees, but often an abundance of bunch-grass. One of the most interesting localities of this zone is found above San Francisco el Alto on the road to Momostenango from Totonicapán. The hills are here covered with tall bunch-grass, while trees are entirely absent. Other somewhat similar savannas are found in the sierra of Huehuetenango and above Totonicapán on the road to Guatemala. In the Huehuetenango sierra the grassy plains are broken here and there by rocky ridges with low pines and numerous thickets of agave. While the soil in the pine lands and in the arboreal zone generally surrounding the savannas is of reddish clay, the savannas themselves consist of an intensely black, loose, and very fertile soil, utilized in places for the cultivation of potatoes and corn. It has already been stated that above the limits of the arboreal zone on the volcanic peaks we find a thousand-foot high zone. Besides the wide belt characterized by bunch-grass and the absence of trees, we find among the rocks and in the shelter of the cañons a fine growth of small tree-ferns in the loose soil, above a stratum which is solidly frozen during a large part of the year. The upper limit of the arboreal zone and the beginning of the savannas lies slightly above 4,000 metres (according to Ed. Rockstroh).

THE BARREN ZONES.

The only barren zones in Guatemala are the very summits of some of the volcanoes, where the ejected sand and ashes have formed steep cones, on which no vegetation can get a foothold. Such barren cones are found on the volcanoes Pacaya, Fuego, Tacaná, and Cerro Quemado. On the latter there is no sand or ashes, the barren region consisting of ejected lava or andesite rocks. Outside of these few places every inch of land in Guatemala is covered with vegetation of some kind, and generally by one of great luxuriance.